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THESIS

A PROPOSAL FOR A MICROCOMPUTER-BASED PHYSICAL QUALIFICATIONS MONITORING SYSTEM FOR THE BRANCH CLINIC, BANCROFT HALL, ANNAPOLIS, MARYLAND

by

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The mission of the Branch Clinic, Bancroft Hall, is to meet the primary health care needs of the Brigade of Midshipmen, U. S. Naval Academy. Equally important, the Branch Clinic must monitor the physical qualifications of those midshipmen and make recommendations to Naval Academy authorities and higher echelon activities regarding their suitability to participate in ongoing professional development activities and for subsequent service as commissioned officers of the Navy and Marine Corps.

This thesis proposes a microcomputer-based Physical Qualifications Monitoring System for the Branch Clinic. Developed as a prototype, the system would provide the clinic staff with their first significant hands-on experience with current information systems technology and serve as a basis for a more fully developed microcomputer-based system or as a preliminary requirements

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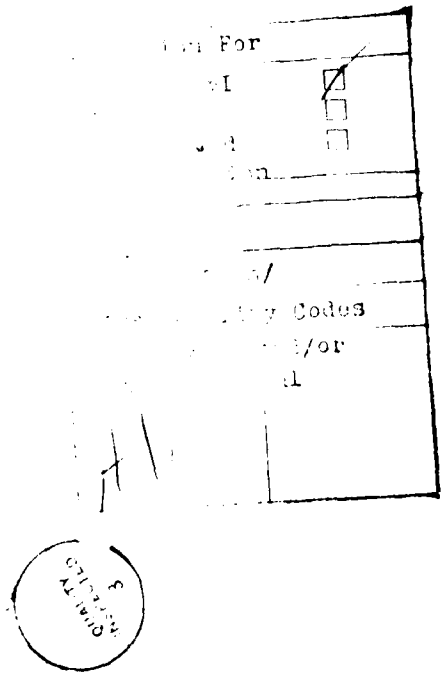
specification for a mainframe-based system.



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A Proposal for a Microcomputer-Based Physical Qualifications Monitoring System for the Branch Clinic, Bancroft Hall, Annapolis, Maryland

by

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ABSTRACT

The mission of the Branch Clinic, Bancroft Hall, is to meet the primary health care needs of the Brigade of Midshipmen, U. S. Naval Academy. Equally important, the Branch Clinic must monitor the physical qualifications of those midshipmen and make recommendations to Naval Academy authorities and higher echelon activities regarding their suitability to participate in ongoing professional development activities and for subsequent service as commissioned officers of the Navy and Marine Corps.

This thesis proposes a microcomputer-based Physical Qualifications Monitoring System for the Branch Clinic. Developed as a prototype, the system would provide the clinic staff with their first significant hands-on experience with current information systems technology and serve as a basis for a more fully developed microcomputer-based system or as a preliminary requirements specification for a mainframe-based system.

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I. INTRODUCTION

The mission of the Branch Clinic, Bancroft Hall, is to meet the primary health care needs of the Brigade of Midshipmen, U. S. Naval Academy. Equally important, the Branch Clinic must monitor the physical qualifications of those midshipmen and make recommendations regarding their suitability to participate in professional development activities and for subsequent service as commissioned officers of the Navy and Marine Corps. These recommendations are provided to both Naval Academy authorities and higher echelon acitivies (e.g., Naval Aerospace Medical Institute, Naval Medical Command, Naval Military Personnel Command, Commandant of the Marine Corps).

To date, the Branch Clinic has monitored physical qualifications without data processing support. This thesis proposes a microcomputer-based Physical Qualification Monitoring System (PQMS) to augment existing manual procedures. The system is designed to help the Branch Clinic answer inquiries on the physical status of midshipmen and in preparing precommissioning physical examinations. Developed as a prototype, this system would provide the clinic staff with their first significant experience with current information systems technology. The proposed PQMS could, in turn, serve as the basis for a more fully

developed microcomputer-based system or as a preliminary requirements specification for a mainframe-based system.

The thesis first describes the organizational context and overviews the problem. These sections are based primarily on personal experience as Administrative Officer, Branch Clinic, Bancroft Hall, during the period January 1982 through July 1984, supplemented by telephone conversations with the current staff and a site visit during December 1985. Next, general characteristics of the PQMS proposal are examined, including design objectives methodology. The system outputs are then discussed, followed by the data structures and processing modules. The summary presents the proposed hardware/software configuration of the system, highlights what PQMS is and is not, and offers some possible extensions to underlying concepts.

The reader will find that this thesis is more pragmatic than theoretic. The information systems concepts are well-established in the literature; no new theory or technology is required or advocated. Rather these concepts are simply brought to bear on a real-life problem which has thus far gone unaddressed. Where appropriate, theory is discussed, but only to a level consistent with the needs of the reader. Every effort is made to focus on the problem, without obscuring key issues with unwarranted detail.

II. ORGANIZATIONAL CONTEXT

A. MISSION AND ORGANIZATION OF THE U. S. NAVAL ACADEMY

The mission of the U. S. Naval Academy (USNA) is to prepare midshipmen for service as commissioned officers of the Navy and Marine Corps. To accomplish this, particular emphasis is placed on the development of a midshipman as a whole--academically, professionally, morally, and physically [Ref. 1:p. 22]. The organization of the Naval Academy reflects this proven approach.

The Superintendent has overall responsibility for the Naval Academy and its large support complex. His principle assistants for the general administration of the Annapolis Area complex are his immediate personal staff, the Deputy for Operations, and the Deputy for Management. Regarding matters specific to the Brigade, the Dean of Admissions, Academic Dean, and Commandant of Midshipmen assist the Superintendent in the recruitment and subsequent academic and professional development of midshipmen.

Of these, the Commandant of Midshipmen is most directly involved with the day-to-day functioning of the Brigade and responsible for the uniquely military aspects of midshipmen development--professional, moral, and physical [Ref. 1:p. 24]. Several departments under the Commandant assist him with this task. The Division of Professional Development

(PRODEV) conducts ongoing training in professional areas, such as leadership, military law, seamanship, and navigation. This division also coordinates the summer cruise program, providing midshipmen with operational experience with fleet and shore-based units of the Navy and Marine Corps, and the service selection process by which individuals choose the warfare specialty in which they will serve subsequent to graduation. The Brigade Officers and Brigade Chaplains share responsibility for the moral development of midshipmen through a blend of religious activities, leadership, guidance, and personal example. The physical development of the Brigade is primarily handled by the Physical Education Department, which provides formal physical education courses and coordinates an extensive intercollegiate and intramural sports program.

The organization of the Brigade of Midshipmen itself also contributes to accomplishment of the Naval Academy mission. The Brigade is divided into six battalions, each headed by a senior officer (rank of O-5 or O-6) of the Navy or Marine Corps. A battalion, in turn, consists of six companies, each under command of a Company Officer from the Navy or Marine Corps (rank of O-3 or O-4). The company is the basic organizational unit of the Brigade and consists of approximately 125 midshipmen. Midshipmen from all four classes (or year group levels) are assigned to each company. [Ref. 1: p.24]

B. MISSION AND ORGANIZATION OF THE NAVAL MEDICAL CLINIC AND BRANCH CLINIC, BANCROFT HALL

The Naval Medical Clinic (NMCL), Annapolis, is a tenant command of the U. S. Naval Academy, responsible for providing general/specialized outpatient clinic services primarily for active duty Navy and Marine Corps personnel, midshipmen, and active duty members of other Federal Uniformed Services. NMCL Annapolis also provides outpatient care to other eligible beneficiaries of the Annapolis Area complex (e.g., dependents of active duty personnel, retirees and their dependents, etc.) on a space-available basis. This activity is organized under a Commanding Officer who reports directly to the Commander, Naval Medical Command, National Capital Region, Bethesda, Maryland, and to the Superintendent, USNA, for additional duty and area coordination. [Ref. 2]

NMCL Annapolis is physically and functionally divided into two distinct units, the Main Clinic and Branch Clinic, Bancroft Hall. The Main Clinic is off the main USNA campus in the buildings which formerly comprised the Naval Hospital, Annapolis. In general, this unit consists of the Office of the Commanding Officer, all administrative support elements of the command, ancillary support services (i.e., Laboratory Pharmacy, and Radiology), and those clinical services provided primarily for non-active duty beneficiaries, such as Primary Care, Pediatrics, and Occupational Health.

The Branch Clinic is on the main campus of the Naval Academy in the basement of Bancroft Hall, the dormitory facility for the Brigade of Midshipmen. This clinic is organized under the Senior Medical Officer and corsists of several small, but distinct work centers, including Military Sick Call, Physical Examinations, Treatment Room, Observation Ward, Orthopedics/Sports Medicine, Physical Therapy, Optometry, and satellites of the ancillary support services at the Main Clinic. The primary beneficiaries of the Branch Clinic are the Brigade and the active duty staff of the Naval Academy.

C. NAVAL ACADEMY/BRANCH CLINIC RELATIONSHIP

The Senior Medical Officer reports directly to the Commanding Officer, NMCL Annapolis. Due to the close relationship between the Naval Academy and Branch Clinic, however, the Senior Medical Officer also has additional duty orders to the Superintendent. This relationship has three dimensions which parallel the "life cycle" of a midshipman.

First, the Senior Medical Officer is a member of the USNA Admissions Board. Each year this board, chaired by the Superintendent, reviews the qualifications of the 14,000+ applicants for admission to the Naval Academy to arrive at a plebe (freshman) class of approximately 1300. The Senior Medical Officer's role on this board is to establish the medical qualifications of the applicants. The principle

vehicle for that determination is the candidate medical examination, conducted under the auspices of the Department of Defense Medical Examination Review Board (DODMERB). An interservice agency, DODMERB is responsible for scheduling the medical examinations for candidates to all service academies and ROTC programs and for making preliminary determinations on the medical status of the candidates. DODMERB forwards their findings for use by the USNA Admissions Board. The Senior Medical Officer advises the Board regarding medical standards and the implications of waivering those standards on an individual's tenure as a midshipman and on possible limitations to career prospects and duty assignments.

Second, the Branch Clinic is responsible for maintaining the good health of the Brigade of Midshipmen. This is done through routine sick call, specialty clinics, immunizations, screening tests and examinations, and health education programs. When the level of care needed by a midshipman is beyond their capabilities, the clinic staff coordinates that care with nearby military treatment facilities and, if warranted, with civilian facilities.

Finally, the Branch Clinic monitors the physical qualifications of the 4500+ members of the Brigade. This task has both short and long term considerations. On the short term, the Senior Medical Officer must ensure that individuals are medically qualified to perform their duties

on a day-to-day basis and to participate in their physically demanding professional development activities. From a long-term perspective, he must also make recommendations to higher authority regarding their suitability to serve as commissioned officers of the Navy and Marine Corps following graduation.

It is important to note that although the Senior Medical Officer reports to the Superintendent for additional duty, he is more directly influenced by and responsible to the Commandant of Midshipmen for several reasons. Not only is the Commandant invariably a flag officer or flag-selectee, but he is also a line officer, whereas the Senior Medical Officer is junior (specifically, a Captain) and from a staff corps. Both the primary beneficiaries and the building containing the Branch Clinic are under control of the Commandant. Furthermore, those Naval Academy authorities most involved with the daily activities and future careers of the Brigade, the Brigade Officers and Division of Professional Development, also work for the Commandant.

III. PROBLEM STATEMENT/PROPOSED SOLUTION APPROACH

A. PROBLEM OVERVIEW

Throughout an individual's four years as a midshipman, much pertinent information is documented in the Health Record regarding physical qualifications. Sources include the candidate physical examination for admission into the Naval Academy; documentation of routine health care; hospitalization and surgery reports; Medical Boards; and special purpose screenings, tests, and examinations. However, this information has never been fully integrated to provide readily accessible physical qualification profiles on the Brigade. The only means of obtaining even a preliminary indication of a midshipman's physical qualification status is to review that individual's Health Record vis-a-vis the physical standards established by higher authority. This is a time-consuming process which currently must be repeated for each separate inquiry and requires detailed knowledge of physical standards by the reviewer. When requests are received for information involving large segments of the Brigade (e.g., Which midshipmen in a given year group are physically qualified for duty as Naval Aviators or Naval Flight Officers?), the Branch Clinic must manually review all pertinent Health Records to respond, often to the exclusion of other work.

Due to the Health Record layout, this review process can lead to important data being overlooked, especially when the reviewers are inexperienced. This is of particular concern since the Branch Clinic must augment its staff with health care providers from other naval medical facilities and Naval Reserve units to complete the annual precommissioning physical examination evolution. Although these providers are competent in their own right, they are often unfamiliar with current standards and the exacting requirements of these physical examinations and are apt to overlook critical data in the Health Record.

B. PROPOSAL

Given the volume of queries and physical examinations handled by the Branch Clinic each year, the need exists for current, easily retrievable physical qualification profiles on all midshipmen. This thesis proposes a microcomputer-based Physical Qualification Monitoring System (PQMS) to meet that need. With such a capability, the Branch Clinic would be more responsive to inquiries from Naval Academy authorities regarding the physical qualifications of midshipmen. Additionally, the accuracy of precommissioning physical examinations generated by the Branch Clinic would be enhanced, so that midshipmen are recommended for only those warfare specialties they are physically qualified for.

C. SECONDARY DESIGN OBJECTIVES

Several secondary objectives motivated the design of the prototype Physical Qualifications Monitoring System. The most important of these are presented below in their approximate order of importance:

1. Minimize the risk exposure of the Branch Clinic.

At least three factors affect the degree of risk in any information systems project [Ref. 3:pp. 313-314]:

- Project size (the larger the project, the greater the risk),
- Experience with the technology to be employed (the greater the prior experience, the lesser the risk--and vice versa), and
- Project structure (the more well-defined and fixed the system outputs, the lesser the risk).

Clearly, all risk cannot be avoided. This is especially true in this instance with regard to experience with the technology.

Nolan has identified four phases of organizational learning relevant to information systems technology. These range from identifying a technology of potential value to an organization and undertaking a pilot project (Phase 1) to widespread technology diffusion where experience in one branch of an organization is easily transferred to other branches (Phase IV). [Ref. 3:p. 30] The only known automated data processing experience of the Branch Clinic is the use of punched cards for immunization evolutions and the casual use by a limited number of staff of the Brigade

Roster System on the Naval Academy Time-Sharing System to generate rosters of midshipmen.

According to Nolan's scheme, then, the clinic is clearly at the beginning of Phase I, where the risks to an organization are inherently higher. To counteract this, emphasis focused on the other two risk factors. The outputs of the system were identified early and fixed in both form and content. By keeping these outputs to the minimum needed to evaluate the PQMS prototype and meet the reporting needs of the Branch Clinic, the project was also kept to a manageable size.

2. Minimize the time investment to learn and to use the prototype.

Key to the acceptance of any system is that the users be able to learn and use the system quickly. To achieve this, the PQMS Users' Manual is less than 40 pages long and provides step-by-step instructions for all processing modules, including very detailed explanation of those off-line procedures involving the Naval Academy Time-Sharing System. The system is itself menu-driven so that the user need not understand the underlying programs and programming language. Personal data (e.g., name, Social Security number, date of birth, etc.) is downloaded from existing Naval Academy files so that this data does not have to be rekeyed or maintained by the Branch Clinic staff.

3. Provide mechanisms for data security.

Although PQMS is a prototype, the system stores personal data covered by the Privacy Act of 1974 and sensitive medical information. Security against unauthorized access, therefore, is a prime concern, so appropriate safeguards are part of the design. Users must enter a password to log onto the system, and the password can be easily changed once successfully logged on. Privacy Act Warning statements are displayed on entering and exiting the program. Two types of reports are provided, detailed reports for use within the Branch Clinic and summary reports for distribution outside the clinic.

4. Provide a repository for current physical standards information.

Continuity is a problem at any military activity due to the frequent rotation of personnel. The Branch Clinic is no exception, with a new Senior Medical Officer and Head, Physical Examinations Department, reporting aboard every few years. Therefore, the PQMS was designed to store detailed physical standards information which would be preserved despite staff changes.

D. DESIGN METHODOLOGY

To facilitate development of the PQMS, considerable thought was devoted to which of two common design methodologies to use: i) data flow-oriented, ii) data structure-oriented. The former, data flow-oriented design,

considers information as a continuous "flow" from input through a series of transforms (processes) to output. This data flow is mapped to provide a representation of software structure. [Ref. 4:pp. 178-179]

Although data flow-oriented design can be used for a broad range of applications and is probably more widely documented in the literature, a data structure-oriented design approach was chosen for PQMS. This was primarily due to the well-defined structure of the inputs, data base files, and outputs of the system. Data structure-oriented design proposes that where such well-defined structures exist, they can be used as the basis for software development. Rather than considering data flows and data flow diagrams, this approach transforms representations of data structure into representations of software structure. The procedural aspects of processing modules are essentially a by-product of data structure. [Ref. 4:pp. 205-207]

IV. PQMS OUTPUTS

The intent of the Physical Qualifications Monitoring System is to provide current, easily retrievable physical qualification profiles on all Naval Academy midshipmen. The form and content of these profiles, in turn, are based on the information needs of both the direct users (the Branch Clinic staff) and indirect users (all others to whom information from the system is provided).

PQMS provides information at two levels of detail. To answer inquiries on specific midshipmen and to facilitate the annual precommissioning physical examination evolution, detailed reports are needed. These show not only an individual's physical qualification status by warfare specialty, but also the disqualifying conditions, standards, and waivers which underlie those determinations. To answer inquiries from outside the clinic on organizational segments of the Brigade, such as a company or year group, summary reports which show physical qualification status by warfare specialty are adequate. The next two sections discuss the specific format and content of these detailed and summary reports.

A. DETAILED REPORTS

Figure 1 shows the general format of the detailed reports produced by PQMS.

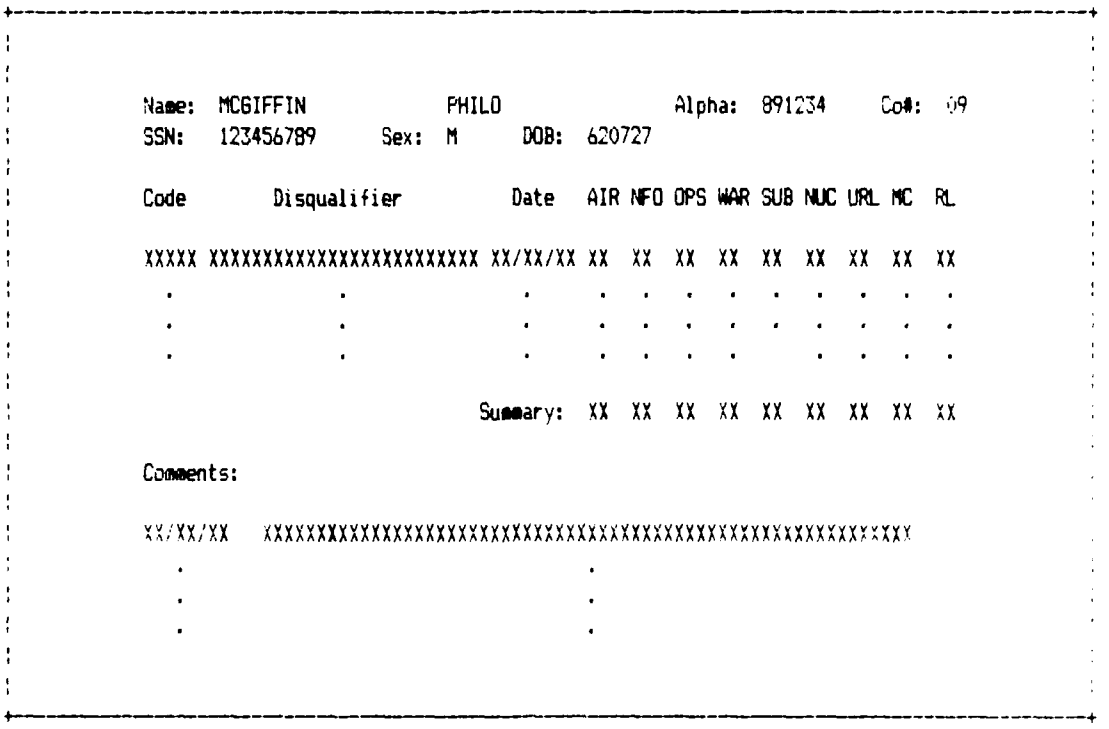


Figure 1. Detailed Physical Qualification Status Report

The heading data on this report is self-explanatory, except for "Alpha:." The alpha number is a numeric identifier assigned to each midshipman on entry into the Naval Academy and is the key for most records maintained by the Naval Academy. It is formed by concatenating the last two digits of midshipman's year group with a four-digit number representing the alphabetized position of that person's name within the Brigade.

The next section of the report is a detailed and summarized listing of physical qualification status information. For each disqualifying condition recorded for a midshipman, a text description and date stamp (reflecting

how current that entry is) is shown. In addition, a set of "flags" reflects the impact of that disqualifier on the midshipman's eligibility for the various warfare specialties. The column headers for these flags represent the following specialty groups:

AIR - Naval Aviator
NFO - Naval Flight Officer
OPS - Special Operations
WAR - Special Warfare
SUB - Submarine Duty
NUC - Surface Nuclear
URL - Unrestricted Line
MC - Marine Corps
RL - Restricted Line/ Staff Corps

The flags themselves can assume one of the following values:

PQ - physically qualified

WG - not physically qualified/waiver granted by higher authority

LW - not physically qualified/limited waiver granted by higher authority

WR - not physically qualified/waiver requested from higher authority

UE - undergoing evaluation/status indeterminate at this time

NQ - not qualified

The summary flags show the overall impact of the individual flags on a midshipman's physical qualification status for each warfare specialty.

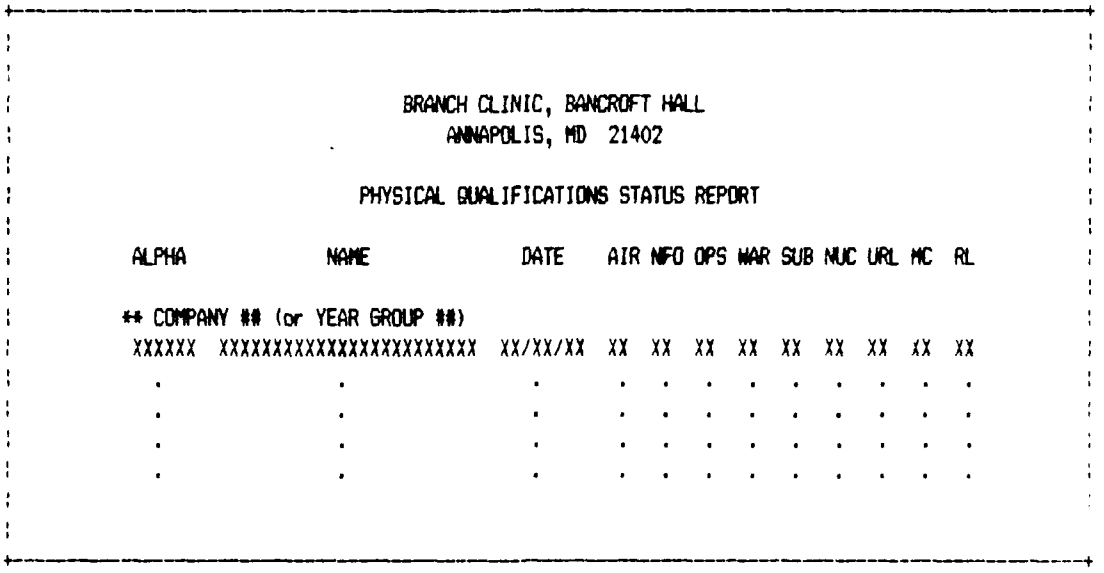
The final section of the detailed report displays free-text comments. These are limited to 60 characters each, date stamped, and provide information specific to a midshipman which the POMS cannot otherwise store.

The detailed report format is generic and can be generated three different ways. First, a single report can be displayed on the CRT screen of the microcomputer. Because of the 80 x 25 character size limitation of a CRT, the report is split into two screens, one containing the header and disqualifier information and the other containing any comments. Second, the user can direct the output to an attached printer, producing a single-sheet report. Finally, a series of detailed reports on all midshipmen in a given company and year group can be directed to the printer. This option is primarily intended to facilitate the annual precommissioning physical examination process by providing reports in the same logical unit that the examinations are processed.

B. SUMMARY REPORTS

Figure 2 shows the general format of the summary reports produced by PQMS.

Given the discussion of the prior section, the contents of this report need no additional explanation. The report simply shows physical qualification summaries for whichever of two categories of midshipmen is chosen, either a year group sorted by company or a company sorted by year group. In both cases, each distinct subgroup (company or year group, respectively) is listed on a separate sheet of paper.



BRANCH CLINIC, BANCROFT HALL
ANNAPOLIS, MD 21402

PHYSICAL QUALIFICATIONS STATUS REPORT

ALPHA	NAME	DATE	AIR	NFO	OPS	WAR	SUB	NUC	URL	MC	RL
** COMPANY ## (or YEAR GROUP ##)											
XXXXXX	XXXXXXXXXXXXXXXXXXXXXXXX	XX/XX/XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
.	.	.	.	.	.	.	.	.	.	.	.
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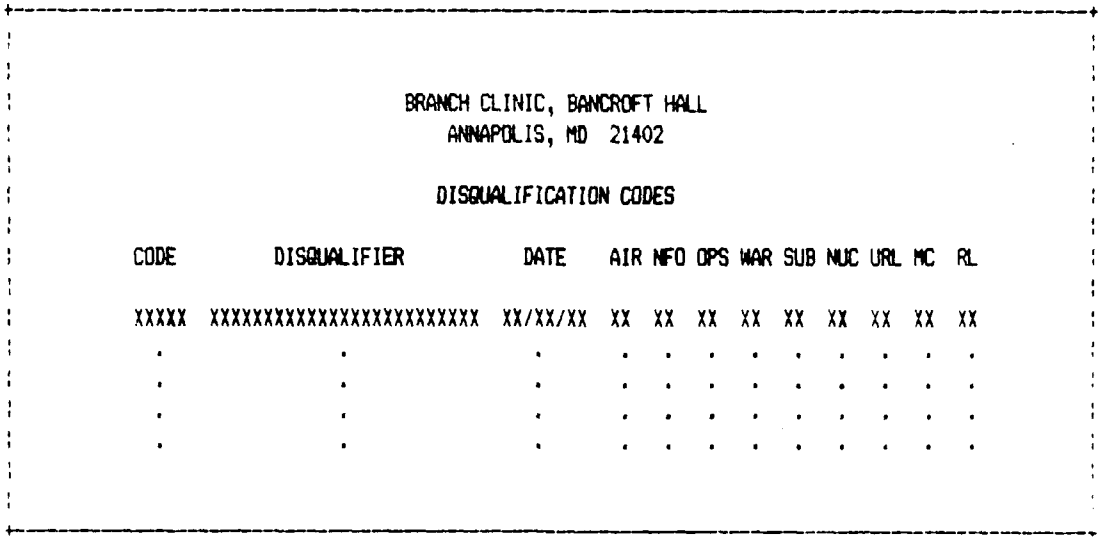
Figure 2. Summary Physical Qualification Status Report

C. DISQUALIFICATION CODES REPORT

The PQMS can also produce printouts of its data base of physical standards in the format shown in Figure 3. The code listed in this report is a five-character, alphanumeric identifier which uniquely identifies each standard in the data base. The text description, date stamp, and flag fields are analogous to those of the detailed physical qualification status report with one exception. The flags can only assume values of PQ or NQ. The standards data file is discussed in greater detail in the next chapter.

PQMS can sort and print these listings either by code or alphabetically. The report is designed for use as a reference guide when recording disqualifiers for midshipmen, eliminating the need to commit the codes and text



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DISQUALIFICATION CODES

CODE	DISQUALIFIER	DATE	AIR	NFO	OPS	WAR	SUB	NUC	URL	MC	RL
XXXXX	XXXXXXXXXXXXXXXXXXXXXXXX	XX/XX/XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.

Figure 3. Disqualification Codes Report

descriptions to memory. In addition, the listings can be distributed outside the Branch Clinic, either as a reference guide for the indirect PQMS users or for validation of the standards data by higher authority (e.g., Naval Aerospace Medical Institute or Naval Medical Command).

V. DATA STRUCTURES

The data structures of the Physical Qualifications Monitoring System provide the basis for the outputs and processing modules of the system. These structures are based on the relational data base model and implemented using the popular microcomputer product, dBASE III. This chapter provides a brief overview of this model and then a detailed discussion of the five PQMS data base files: BRIGADE, STANDARDS, DISQUALIFIERS, COMMENTS, and SUMMARY.

A. OVERVIEW OF RELATIONAL DATA BASE MODEL

The relational model uses two-dimensional tables to represent data. These tables (or relations) have several important properties. Each entry in the table can contain only a single-value; repeating groups or arrays cannot be used as entries. Each column has a unique name and is called an attribute or field. All entries within a column are of the same type and come from the same domain of permissible values. The rows of the relation are the individual records of the data base file. No two rows in the table may be identical, and each row is identified by a unique key formed by some attribute or combination of attributes from the relation. The relational model not only requires each record to have a primary key, but also permits alternate keys if they too are unique. [Ref. 5:pp. 243-245]

As is the case with the PQMS, a data base usually consists of several different relations or tables. Key questions are then: What kinds of relationships can exist among the tables and how are they represented? There are three basic types of relationships. A tree, also known as a hierarchy, consists of a collection of records and one-to-many relationships among records. Each record can have one and only one parent. A simple network relaxes this definition slightly, so that a record can have more than one parent so long as they are of different types. Lastly, a complex network consists of a collection of records and many-to-many relationships (i.e., records may have multiple parents including some which are of the same type). [Ref. 5:p. 117-122] As illustrated later in this chapter, PQMS uses both the tree (between the BRIGADE and COMMENTS data base files) and complex network (between the BRIGADE and STANDARDS data base files).

Just as different types of relationships may exist among relations, so too can the relationships be represented in various ways. The relational model is noteworthy in that the table entries themselves identify any relationships, rather than requiring them to be explicitly defined when the logical format of the data base is first specified. The table entries typically used for this purpose are the record keys (or portions of them), although this is not always

true. Relationships among the PQMS data base files are defined exclusively by record keys.

B. BRIGADE DATA BASE FILE

The BRIGADE data base file contains personal, non-medical data on each midshipman. Figure 4 describes this file. The data elements are a subset of those contained in the Brigade Roster File (BROSTER), a well-established data base maintained by the Midshipman Personnel Office. The procedural aspects of downloading this data to the PQMS microcomputer are given in the next chapter.

Two keys are used for BRIGADE, Alpha and SSN. Both are unique and allow the user more flexibility in querying PQMS. In addition, the file is indexed (i.e., sorted) on three different fields, Alpha, SSN, and the concatenation of Company+Alpha, to accelerate search routines and overall program execution, as well as to properly sequence printed outputs.

C. STANDARDS DATA BASE FILE

Figure 5 describes the STANDARDS data base file. In essence, this file is the Branch Clinic's corporate memory of the physical standards contained in the Manual of the Medical Department and other pertinent directives. Each record in STANDARDS includes a unique code established by the Branch Clinic, a text description of the disqualifying condition, and a series of nine flags which reflect the

Data Base File: BRIGADE

Description: Personal, non-medical data on each midshipman

Data Elements:

Field Name	Type	Length	Remarks:
Alpha	Char	6	The first two digits of the alpha number are the last two digits of the year in which the midshipman will graduate. The remaining four digits are reflect the alphabetized position of the midshipman's name within the Brigade, without regard to year of graduation. EXAMPLE: 891234
SSN	Char	9	Social Security Number of midshipman, non-hyphenated. EXAMPLE: 123456789
Last	Char	20	Last name of midshipman, in all capital letters and padded with blanks to the right as necessary. EXAMPLE: MCGIFFIN
First	Char	15	First name of midshipman, in all capital letters and padded with blanks to the right as necessary. EXAMPLE: PHILO
Sex	Char	1	Sex of midshipman, M (male) or F (female). EXAMPLE: M
DOB	Char	6	Midshipman's date of birth, YYMMDD format. EXAMPLE: 620727
Company	Char	2	Company to which midshipman is assigned, expressed as two digits (01,...,36). EXAMPLE: 09

Primary Key: Alpha
Alternate Key: SSN

Indexes: Alpha, SSN, Company+Alpha

Figure 4. Description of BRIGADE Data Base File

Data Base File: STANDARDS

Description: Physical standards from the Manual of the Medical Department and other pertinent directives

Data Elements:

Field Name	Type	Length	Remarks:
Code	Char	5	Alphanumeric code based on International Classification of Diseases, 9th Edition, Clinical Modification, which uniquely identifies the disqualifying condition. EXAMPLE: 36850
Text	Char	25	Text description of the disqualifying condition, using generally accepted medical terminology and abbreviations as needed to restrict the description to 25 characters or less. EXAMPLE: COLOR VISION DEFICIENCY
AIR_std	Char	2	Flag which indicates whether the disqualifying condition would render a midshipman physically qualified (PQ) or not physically qualified (NQ) for duty as a student naval aviator. EXAMPLE: NQ
NFO_std	Char	2	* SAA, except student naval flight officer.
OPS_std	Char	2	SAA, except special operations duty.
WAR_std	Char	2	SAA, except special warfare duty.
SUB_std	Char	2	SAA, except submarine duty.
NUC_std	Char	2	SAA, except surface nuclear duty.
URL_std	Char	2	SAA, except unrestricted line.
MC_std	Char	2	SAA, except U. S. Marine Corps.
RL_std	Char	2	SAA, except restricted line/staff corps.
Date	Date	8	Date of most recent update to standard, MM/DD/YY format. EXAMPLE: 03/27/86

Primary Key: Code

* SAA - Same as above

Indexes: Code, Text

Figure 5. Description of STANDARDS Data Base File

impact of that condition on a midshipman's physical qualification for the various warfare specialties. The record also carries a date stamp showing when the entry was most recently updated. The key for STANDARDS is the Code field, and the file is indexed on both the Code and Text fields.

Some attributes of the STANDARD data base file warrant further elaboration. The Code field has been designed to accommodate the coding scheme of the International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM). Basically, ICD-9-CM categorizes diseases and injuries and assigns a five-digit code to each. The first three digits identify the system of the body affected; the last two digits add the necessary detail to identify the specific disease or injury. Figure 6 shows the major classifications of ICD-9-CM and their three-digit rubrics. [Ref. 6]

The ICD-9-CM coding scheme was chosen for two reasons. First, ICD-9-CM is used throughout the Navy to classify morbidity and mortality information for statistical reports and to index medical treatment records by disease or injury. Therefore, the coding scheme is a familiar one and eliminates the need to develop a scheme unique to PQMS. Second, DODMERB is currently developing a new dictionary of disqualification codes based on ICD-9-CM, which the Branch Clinic could adapt to meet their own needs. This would both

Code Series	Classification
00100 - 13999	Infectious and Parasitic Diseases
14000 - 23999	Neoplasms
24000 - 27999	Endocrine, Nutritional, and Metabolic Diseases and Immunity Disorders
28000 - 28999	Diseases of the Blood and Blood-Forming Organs
29000 - 31999	Mental Disorders
32000 - 38999	Diseases of the Nervous System and Sense Organs
39000 - 45999	Diseases of the Circulatory System
46000 - 51999	Diseases of the Respiratory System
52000 - 57999	Diseases of the Digestive System
58000 - 62999	Diseases of the Genitourinary System
63000 - 67699	Complications of Pregnancy, Childbirth, and the Puerperium
68000 - 70999	Diseases of the Skin and Subcutaneous Tissue
71000 - 73999	Diseases of the Musculoskeletal System and Connective Tissue
74000 - 75999	Congenital Anomalies
76000 - 77999	Certain Conditions Originating in the Perinatal Period
78000 - 79999	Symptoms, Signs, and Ill-Defined Conditions
80000 - 99999	Injury and Poisoning

SOURCE: International Classification of Diseases, 9th Edition, Clinical Modification, Commission on Professional and Hospital Activities, Ann Arbor, Michigan, March 1980.

Figure 6. Classification of Diseases and Injuries

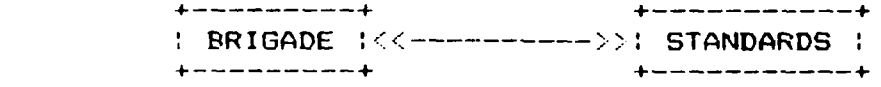
enhance consistency among these related systems and facilitate the recording of medical problems identified by DODMERB on the candidate medical examination into the PQMS data base.

The domain of the flag fields in the STANDARDS data base file consists of only two possible values: PQ (physically qualified) or NQ (not physically qualified). At first, this

may seem unduly restrictive, since it implies that standards are absolute and disregard individual circumstances. Actually, these values are merely endpoints on a continuum and provide a first-cut determination of an individual's physical qualification status. As discussed in the next section, these flags can be modified by those of the DISQUALIFIERS data base file to reflect specific situations, such as not physically qualified/waiver granted, not physically qualified/waiver requested, etc.

D. DISQUALIFIERS DATA BASE FILE

A complex relationship exists between the BRIGADE and STANDARDS data base files. This means that each midshipman record can be related to many standards (i.e., a midshipman can have more than one disqualifying condition) and each standard can be related to many midshipmen (i.e., more than one midshipman can have a certain disqualifying condition). This many-to-many relationship can be illustrated as:

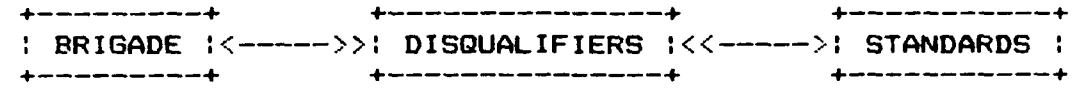


Note the two-headed arrows pointing in both directions, indicative of a complex relationship.

Complex relationships are awkward to implement, so the relational model decomposes such relationships using an intersection record. As the name implies, this record represents the merger, or "intersection," of two other

records [Ref. 5:p. 145]. PQMS uses the DISQUALIFIERS data base file for this purpose.

The resulting simple network can be represented as:



Note that the two resulting relationships are one-to-many, denoted by single-headed arrows pointing toward BRIGADE and STANDARDS. This means that each record in DISQUALIFIERS can have only one parent in BRIGADE and one in STANDARDS.

Figure 7 describes the DISQUALIFIERS data base file. This file contains a unique record for each instance where a midshipman is identified to have a disqualifying condition. The key for these intersection records is the combination of the midshipman's alpha number and code assigned to the disqualifying condition (i.e., Alpha+Code). Each record also has a series of flags corresponding to the nine warfare specialty categories. These are the flags which relax the rigid PQ/NQ flags of the STANDARDS file. For each warfare specialty, the flags from STANDARDS and DISQUALIFIERS are compared. If the STANDARDS flag is PQ, the condition is not disqualifying for that particular warfare specialty, so the DISQUALIFIERS flag is irrelevant and the resulting status flag is PQ. However, if the STANDARDS flag is NQ, it could be modified by any DISQUALIFIERS flag. If the corresponding DISQUALIFIERS flag is WG, LW, or WR the resulting status flag would also be WG, LW, or WR, respectively. If the

Data Base File: DISQUALIFIERS

Description: Intersection file which decomposes the complex relationship between BRIGADE and STANDARDS into a simple network.

Data Elements:

Field Name	Type	Length	Remarks:
Alpha	Char	6	Alpha number of the midshipman to whom the disqualifier is assigned.
Code	Char	5	Code of the disqualifying condition assigned to the given midshipman.
AIR_waiver	Char	2	Flag which may modify the corresponding flag from the STANDARDS data base file for duty as a student naval aviator (i.e., AIR_std). Permissible values include: WG - not physically qualified/waiver granted LW - not physically qualified/limited waiver granted WR - not physically qualified/waiver requested UE - undergoing evaluation/status indeterminate at this time If none of the foregoing flags apply, the field is left blank.
NFO_waiver	Char	2	* SAA, except student naval flight officer.
OPS_waiver	Char	2	SAA, except special operations duty.
WAR_waiver	Char	2	SAA, except special warfare duty.
SUB_waiver	Char	2	SAA, except submarine duty.
NUC_waiver	Char	2	SAA, except surface nuclear duty.
URL_waiver	Char	2	SAA, except unrestricted line.
MC_waiver	Char	2	SAA, except U. S. Marine Corps.
RL_waiver	Char	2	SAA, except restricted line/staff corps.
Date	Date	8	Date of most recent update to entry, MM/DD/YY format.

Primary Key: Alpha+Code

* SAA - Same as above

Indexes: Alpha, Code

Figure 7. Description of DISQUALIFIERS Data Base File

DISQUALIFIERS flag is blank, there is no modification, and the status flag would be NQ. The only exception to this scheme occurs when the DISQUALIFIERS flag is UE (undergoing evaluation). This means that regardless of what the STANDARDS flag specifies, the midshipman's status is indeterminate at that time, so the resulting status flag would be UE. Figure 8 shows the decision table for this process.

If the STANDARDS flag for a warfare specialty is:	PQ	NQ	NQ	NQ	NQ	PQ or NQ
And the corresponding DISQUALIFIERS flag is:	$\overline{\overline{UE}}$	WQ	LW	WR	..	UE
Then the status flag for that warfare specialty is:	PQ	WQ	LW	WR	NQ	UE

Key: $\overline{\overline{UE}}$ - not UE (i.e., WQ, LW, WR, or blank)
.. - blank

Figure 8. Decision Table for STANDARDS--DISQUALIFIERS Flags

The algorithm for determining a midshipman's overall physical qualification status is slightly different. First, the nine status flags for each disqualifying condition are determined as described in the preceding paragraph. These status flags are then compared within each

warfare specialty. If any single status flag is NQ, the midshipman is not physically qualified for that warfare specialty, and the summary flag evaluates to NQ. Similarly, if no status flags are NQ but at least one is UE, the midshipman's status is indeterminate, and the summary flag evaluates to UE. This process continues in like manner for the WR, LW, and WG flag values. A summary flag evaluates to PQ (physically qualified) if and only if all status flags for the particular warfare specialty are also PQ. Of course, if a midshipman has no disqualifying conditions, then all summary flags evaluate to PQ. Figure 9 illustrates this algorithm.

```
IF (any status flag for a warfare specialty = NQ)
THEN (summary flag = NQ)

ELSE IF (any status flag for that warfare specialty = UE)
     THEN (summary flag = UE)
     ENDIF

ELSE IF (any status flag for that warfare specialty = WR)
     THEN (summary flag = WR)
     ENDIF

ELSE IF (any status flag for that warfare specialty = LW)
     THEN (summary flag = LW)
     ENDIF

ELSE IF (any status flag for that warfare specialty = WG)
     THEN (summary flag = WG)
     ENDIF

ELSE (summary flag = PQ)
ENDIF
```

Figure 9. Algorithm for Determining Summary Flags

Note that because the summary flags are dependent upon the STANDARDS and DISQUALIFIERS flags and therefore subject to relatively frequent change, they are not part of the permanent PQMS data base. Instead, the summary flags are reevaluated each time a detailed or summary report is generated and either immediately displayed to the CRT screen or printer or stored to a temporary data structure as described later.

Finally, in addition to the Alpha, Code, and nine flag fields, each DISQUALIFIERS record has a date stamp which shows how current the data in the record is. As mentioned before, the key is Alpha+Code, and the file is indexed on both the Alpha and Code fields.

E. COMMENTS DATA BASE FILE

Although the BRIGADE, STANDARDS, and DISQUALIFIERS data base files provide a detailed profile of the physical qualification status of each midshipmen, they do not handle all contingencies. Therefore, PQMS also has a COMMENTS data base file which stores information which cannot be otherwise entered into the system. Figure 10 describes this file.

The Alpha field establishes the tree relationship between BRIGADE and COMMENTS; each record in COMMENTS has one and only one parent record in BRIGADE. The Comment field may contain whatever information the user feels is needed to clarify the midshipman's physical qualification

Data Base File: COMMENTS

Description: Information impacting on physical qualification status which cannot otherwise be stored by PQMS.

Data Elements:

Field Name	Type	Length	Remarks:
Alpha	Char	6	Alpha number of the midshipman to whom the comment applies. EXAMPLE: 891234
Comment	Char	60	Comment entered as free text. EXAMPLE: ACL REPAIR SCHEDULED 27JUL86
Date	Date	8	Date comment was entered into data base, MM/DD/YY format. EXAMPLE: 07/13/86

Primary Key: Alpha (nonunique)

Index: Alpha+Date

Figure 10. Description of COMMENTS Data Base File

status, and the date stamp shows when the comment was recorded. No unique key is explicitly defined for COMMENTS, but Alpha serves adequately as nonunique key. The file is indexed on the combined Alpha+Date fields.

F. SUMMARY DATA BASE FILE

The SUMMARY data base file, described in Figure 11, is actually a temporary structure. When a detailed physical qualification status report is generated (see Figure 1), SUMMARY provides a scratchpad for storing intermediate and final results of the summary flags algorithm of Figure 9.

Data Base File: SUMMARY

Description: Temporary data base file which stores personal data and summary flags for detailed or summary physical qualification reports

Data Elements:

Field Name	Type	Length	Remarks:
Alpha	Char	6	Alpha number of the midshipman.
Name	Char	25	Last and first names of the midshipman, separated by a comma and truncated. EXAMPLE: MCGIFFIN, PHILO
Company	Char	2	Company to which midshipman is assigned.
AIR_flag	Char	2	Summary flag which indicates midshipman s physical qualification for duty as a a student naval aviator. Permissible values include: PQ - physically qualified; WG - not physically qualified/waiver granted; LW - not physically qualified/limited waiver granted; WR - not physically qualified/waiver requested; UE - undergoing evaluation/status indeterminate at this time; NQ - not physically qualified
NFO_flag	Char	2	* SAA, except student naval flight officer.
OPS_flag	Char	2	SAA, except special operations duty.
WAR_flag	Char	2	SAA, except special warfare duty.
SUB_flag	Char	2	SAA, except submarine duty.
NUC_flag	Char	2	SAA, except surface nuclear duty.
URL_flag	Char	2	SAA, except unrestricted line.
MC_flag	Char	2	SAA, except U. S. Marine Corps.
RL_flag	Char	2	SAA, except restricted line/staff corps.

Primary Key: Alpha

* SAA - Same as above

Index: Alpha or Company+Alpha (depending on report being generated)

Figure 11. Description of SUMMARY Data Base File

When a summary reports are generated (see Figure 2), SUMMARY stores personal data from the BRIGADE file, as well as the results of the summary flag algorithm. In either case, the contents of SUMMARY are erased after the report is produced, leaving only a superstructure which can be reused for the next detailed or summary report.

The Name field in the SUMMARY file is a combination of the midshipman's last and first names, truncated to 25 characters to allow use of the built-in dBASE III report generator for summary reports. The other fields are self-explanatory. The key for SUMMARY is the Alpha field. When summary reports are generated, indexes are created "on the fly" based on either the Alpha or Company+Alpha fields, depending on the desired sort sequence. These indexes are also temporary and erased after the reports are printed.

VI. PRINCIPLES OF OPERATION

Consistent with the data structure-oriented design approach, the PQMS data base files provide the basis for the procedural aspects of the system. In general, a hierarchy of modules exists as illustrated at a first level of detail by Figure 12.

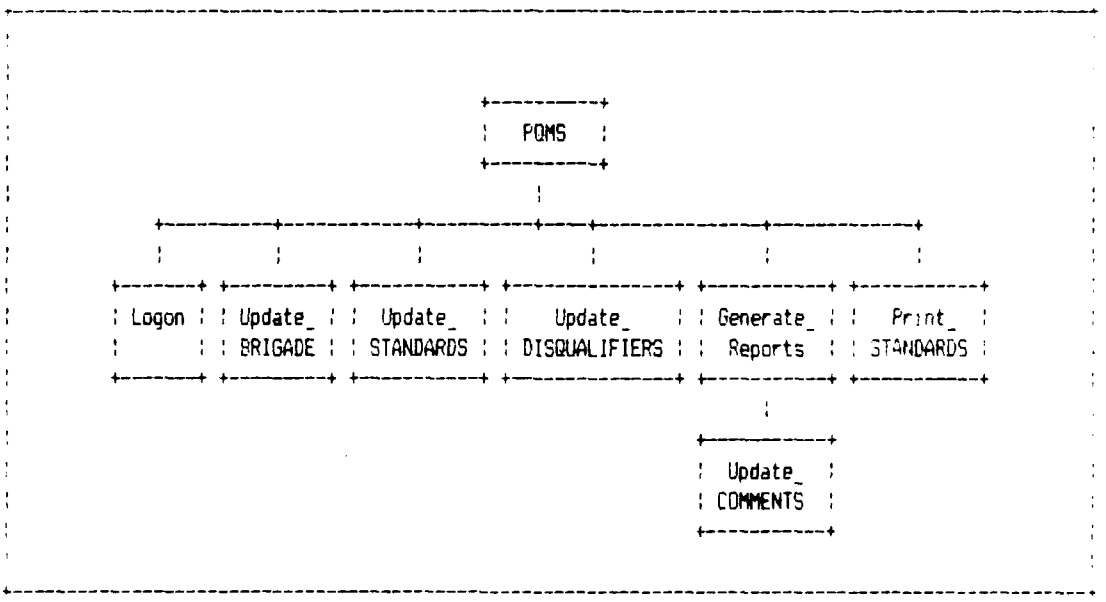


Figure 12. Hierarchy of PQMS Modules

The system is menu-driven, so no knowledge of the underlying dBASE III language or programs is needed to effectively interact with PQMS. Visual and auditory prompts guide the user through all facets of the program, and extensive error-trapping validates inputs and maintains the integrity of the

data bases. The following sections overview the PQMS principles of operation.

A. ENTERING AND EXITING PQMS

To begin using PQMS, the user must first enter a password. (The user gets three attempts at this, after which processing is aborted and control returned to the microcomputer's operating system.) After a successful logon, the user gets an opportunity to change the current password, an action strongly encouraged from time to time to prevent unauthorized access to the system. An introductory banner is displayed, followed by a Privacy Act Warning. PQMS then presents its main menu from which the user invokes the subordinate processing modules. When the user decides to exit PQMS, the Privacy Act Warning is again displayed before control reverts to the operating system.

B. UPDATING PERSONAL DATA

There are actually two phases to updating the personal data in the BRIGADE data base file. The first is an off-line process involving the Naval Academy Time-Sharing System (NATS) and the Brigade Roster File (BROSTER). Running a NATS program called BRIGREAD***, the user creates a file containing the alpha number, Social Security number, last name, first name, sex, date of birth, and company of every member of the Brigade. This file is then downloaded from the NATS Honeywell DPS 8 computer through a 2400-baud,

hard-wired line to the Branch Clinic microcomputer, using the KERMIT communication protocol on both computers to ensure reliable, error-checked data transfer.

When this data is on the hard disk storage unit of the microcomputer, PQMS can update the BRIGADE data base as follows. After ensuring that the new file of personal data is in place, PQMS erases the old BRIGADE data base and its indexes, creates an empty data structure of the appropriate format, appends to that structure from the downloaded file, and reindexes the new BRIGADE data base. PQMS deletes then records in the DISQUALIFIERS and COMMENTS files which no longer have a counterpart in BRIGADE, and control reverts to the main menu.

This process is unlike others in PQMS in that it takes place in batch mode and only periodically, rather than on-line and continuously as is typical of the other updates. This raises a question as to whether the overall performance of PQMS suffers due to the BRIGADE data being outdated. This is not the case at all! Martin has identified five classes of data according to increasing complexity of update [Ref. 7:pp. 281-284]:

Class 0 - Unchanging data

Class 1 - Data which are updated by simple replacement

Class 2 - Data with independent nonrepeatable updates

Class 3 - Data with time-critical updates

Class 4 - Data for which an update may trigger an action in a different machine

The data element of BRIGADE most susceptible to change is Company, which is known to change at the end of the fourth class (freshman) year and on some other rare occasions. All other data elements are unchanging, except for correction of erroneous initial entries. Therefore, the overall classification for BRIGADE is Class 1, in which case the replacement scheme used by PQMS is quite appropriate. Additional benefits are that the Branch Clinic does not have to replicate the substantial efforts of the Midshipman Personnel Office by initially entering or maintaining the data and that consistency between BROSTER and PQMS is assured.

C. UPDATING STANDARDS DATA

Updating the STANDARDS data base file involves three activities: adding, modifying, and deleting standards. When adding to the data base, the user first enters the code for the new standard. The entry is checked to ensure that it is five characters long and than the code has not already been used for any existing standard; the user is reprompted if the code fails either test. If the code is valid, a blank record is appended to STANDARDS, and the user enters a text description for the disqualifier and the standard flags for the nine warfare specialties (i.e., AIR_std, NFO_std, etc.). Each flag is validated as PQ or NQ before proceeding to the next. Before storing and indexing the new record, PQMS

displays all input and asks for confirmation. Based on the user's response, the data is either committed to the data base along with the current date or cleared from memory.

To modify a standard, the user first enters its five-digit code. If the code does not exist, an error message results. Otherwise, PQMS displays the code, text description, and flags for the standard. After confirming that this is the desired record, the user enters a new series of flags, which are also validated as being PQ or NQ. As before, the user must confirm that the new data is to be committed to the data base, at which point the Date field of the record is changed as well.

When attempting to delete a standard, PQMS first checks to see if the code which the user entered exists. If not, an error message results. If it does, the DISQUALIFIERS files is searched to see if any intersection records exist for that code. To maintain data base integrity, PQMS will not delete a standard which has any associated intersection records. Assuming this is not the case, the code, text description, and flags for the standard are displayed. The record is deleted only after approval by the user.

Access to any of these three processes is through the Update_STANDARDS module. Once a subordinate module is entered, the add, modify, or delete cycle continues until a null (blank) is entered at the code prompt. Control then reverts back to the superordinate, Update_STANDARDS module.

D. UPDATING DISQUALIFIERS DATA

Updating the DISQUALIFIERS data base file is similar in several respects to updating STANDARDS. Options include adding, modifying, and deleting disqualifiers. Access to these is through the Update_DISQUALIFIERS menu, and after entering any of the subordinate modules, processing loops within that module until the user responds to the prompt for an alpha or Social Security number with a null value. On the other hand, updating DISQUALIFIERS requires some additional steps due to the inherent complexity of intersection records.

Adding to the DISQUALIFIERS file begins by inputting either the alpha or Social Security number of the midshipman to whom the new disqualifier will be assigned. This flexibility is built into PQMS because Naval Academy authorities typically identify midshipmen by alpha number, whereas the Branch Clinic uses Social Security number almost exclusively to identify Health Records, physical examinations, and the like. Assuming the length of the value provided is valid (i.e., 6 or 9 characters), PQMS chooses either the Alpha or SSN index and searches for the input value. If it is not found, an error message results, reprompting the user for a valid key. Otherwise, PQMS displays the midshipman's full name and company number and asks for confirmation that this is the desired individual. The user then enters the code of the disqualifier to be

assigned to that midshipman. A null value aborts the cycle, and an invalid entry causes reprompting. Another crucial check is made to ensure that an intersection record does not already exist for that midshipman and disqualifier code; if one does, an error message and reprompt are displayed. Next the code, text description, and standard flags for the disqualifier are displayed, and the user enters any waiver flags for the nine warfare specialties (i.e., AIR_waiver, NFO_waiver, etc.). Each input is validated as being WG, LW, WR, UE or blank before continuing to the next waiver flag. POMS then asks the user to approve entry of the new intersection record into the data base and either appends the current date or discards all input.

The preliminary steps in modifying a DISQUALIFIERS record are similar to those above. A valid alpha or Social Security number yields the name and company number of the midshipman. A null code entry aborts the current modification process, while an error message and reprompt occur if an intersection record cannot be found for the given midshipman and disqualifier code. When the intersection record is found, the text description of the disqualifier, standard flags, and existing waiver flags are displayed. The user then inputs the new waiver flags, each of which is validated before continuing to the next. After confirmation, POMS modifies the intersection record to

reflect the new set of waiver flags and current date; otherwise, the record left unchanged.

Deleting a disqualifier is identical to modifying one through the point at which the text description, standard flags, and old waiver flags are displayed. PQMS then either deletes or retains the intersection record, based on the user's confirmation input.

E. GENERATING PHYSICAL QUALIFICATION STATUS REPORTS

The Generate_Reports menu is the starting point for producing detailed or summary physical qualification status reports. The formats of these reports were presented in Figures 1 and 2. Five options are available:

1. Detailed report on one individual (to CRT screen), including adding and deleting comments
2. Detailed report on one individual (to printer)
3. Detailed reports on all midshipmen in a given company and year group (to printer)
4. Summary report on all midshipmen in a given company, sorted by year group (to printer)
5. Summary report on all midshipmen in a given year group, sorted by company (to printer)

These are the most demanding activities performed by PQMS, in terms of both input/output and processing, and consequently the most time-consuming. The sequence of the options roughly corresponds to the increasing complexity of the underlying processing tasks.

A detailed report on an individual, either to the CRT screen or printer, requires only one user input--a valid

alpha or Social Security number. Using either of these, PQMS locates the midshipman record in the BRIGADE data base and displays the personal information contained in that file. Using the individual's alpha number, PQMS then searches the DISQUALIFIERS file for any related intersection records. If none are found, a statement to that effect is produced, and the summary flags for all warfare specialty default to PQ. Otherwise, PQMS uses the DISQUALIFIERS Code field to find the corresponding record in STANDARDS and compares the corresponding pairs of flags using the decision table of Figure 8 (i.e., AIR_std vs. AIR_waiver, NFO_std vs. NFO_waiver, etc.). The code, text description, date of the most recent change to the intersection record, and the nine status flags for that disqualifier are displayed, and the status flags are evaluated using the algorithm for summary flags of Figure 9. This process continues for all disqualifiers assigned to the midshipman. The nine summary flags are then displayed in their final form.

At this point, the procedures for CRT display and printing diverge. In both cases, the alpha number is used to find all related records in the COMMENTS data base. When the detailed report is printed, these are directly output in order from the oldest to most recent. Because of the 80 x 25 character limitation of a CRT screen, however, output pauses after the nine summary flags, and the user is prompted to press any key to clear the screen and display

any comments. This second screen also affords the user the opportunity to delete old comments or add new ones. No error-trapping is used per se. Instead, the comments screen is refreshed after each deletion or addition, after which the user may correct any errors.

During the annual precommissioning physical examination evolution, midshipmen are usually processed in groups based on their company. To facilitate this, PQMS provides the ability to print detailed reports on all individuals in a particular company and year group. The user begins by entering the desired company number, then year group. A null value for either aborts the process. When valid inputs have been entered for both, the reports are printed as described previously for individual detailed reports, each on a separate page and in alphabetical order.

To assist the Brigade Officers and Division of Professional Development in their career counseling roles and in administering the summer cruise and service selection programs, PQMS can produce summary physical qualification status reports on all midshipmen in a particular company or year group. The processing logic for these reports is virtually identical. First, the user enters the desired company (or year group). As before, the input is validated, and a null entry aborts the process. Using the BRIGADE, DISQUALIFIERS, and STANDARDS data bases, PQMS determines the warfare specialty summary flags for each midshipman in the

chosen subset. These are stored in the SUMMARY data structure, along with the midshipman's alpha number, name, and sex. These records are then indexed and printed. The company report lists each year group on a separate page, while the year group report lists each company on a separate page. After either report is printed, the SUMMARY data structure is purged, leaving only its shell for use by for the next report, and the index is erased.

F. PRINTING STANDARDS DATA

The STANDARDS data base file can be printed in its existing form (see Figure 3) as a reference guide for updating the PQMS data base or to allow review by an outside authority. The procedure is straightforward. The user simply chooses whether the listing is to be sorted by code or alphabetically. PQMS then uses the appropriate index and produces a printout of all records in STANDARDS in the desired order.

VII. SUMMARY

A. HARDWARE AND SOFTWARE CONFIGURATION

Systems design consists of two phases, logical design and physical design. So far, this thesis has only dealt with the logical design of the Physical Qualification Monitoring System, addressing design issues such as outputs, inputs, data base files, and procedures. There is nothing which precludes implementation of the PQMS logical design on NATS or any other Naval Academy computer system.

Because of the development environment for the PQMS, however, the system was explicitly designed for implementation on a microcomputer. The hardware and software selected for the PQMS include:

- Televideo XL Portable Computer (with RAM expansion to 512 Kbytes)
- Xebec 10HB External Hard Disk
- Citizen MSP-10 Dot Matrix Printer
- Microsoft MS-DOS (Version 2.11)
- dBASE III (Version 1.1)
- KERMIT Communications System

Actually, once the decision was made to use a microcomputer, there was little choice regarding the hardware and software. Based on a contract awarded to Federal Data Corporation in May 1985, the Televideo XL is now the standard personal microcomputer for the Navy and Air Force. Except for KERMIT

which is public-domain software, the PQMS configuration is based exclusively on that contract.

Federal procurement contracts are often a mixed blessing. This is particularly true of the PQMS. On the positive side, the problem of choosing from the growing number of microcomputers in today's market was eliminated, as were problems stemming from involving multiple vendors when building a system. The built-in serial port allows direct connection of the Televideo XL to the 2400-baud, hard-wired NATS communications lines, and the 10-megabyte external hard disk provides sufficient storage capacity for the PQMS files.

Unfortunately, the Televideo lacks a cassette tape or similar backup facility, so floppy disks are the primary backup medium for the PQMS. Since some of these files (e.g., DISQUALIFIERS, COMMENTS) may exceed the 360-kilobyte capacity of a floppy disk, other alternatives are needed. As an interim measure, larger files can be backed up to NATS, but the long-term solution is a cassette tape backup unit. Another potential problem with the Televideo XL is speed. This microcomputer uses an Intel 8088 microprocessor chip and operates on a 4.77 MHz clock. While these are adequate for some applications, the PQMS detailed physical qualification status reports involve a large volume of input/output and a very heavy processing load, especially if the report is on an entire year group. The hard disk helps

somewhat by speeding up input/output, but the processor speed is the main problem. Potential solutions are to enhance the Televideo with an accelerator expansion card or to upgrade to a faster microcomputer (e.g., IBM PC-AT, Compac DeskPro 286, etc.).

B. POMS AS AN EXPERT SYSTEM

Expert systems have received considerable attention in recent years and are at the heart of what is known as the "fifth generation" of computer technology. These systems are programs which have the knowledge and capability built in to allow them to operate at the expert's level. The two principle components of an expert system are a knowledge base and inference engine. The knowledge base contains both general facts of the problem domain and the heuristic or experiential knowledge of one or more experts from that field. The inference engine is the reasoning process which applies the domain and heuristic knowledge to the situation at hand to find an answer or solution. Many inference engines are generic in that they can be used with different knowledge bases to address problems from a variety of domains. [Ref. 8:pp. 63-64, 76-79]

The POMS is not designed as an expert system. Its reasoning processes are part of the program and cannot be segmented out for general use in other domains. However, the system closely mimics an expert system through its

ability to make physical qualification determinations using stored knowledge, to explain those determinations via its detailed reports, and to pass on knowledge from one generation of user to the next.

C. PQMS AS A PROTOTYPE

Prototyping is a term long associated with the more mature engineering fields. For example, automobile and aircraft manufacturers have for years developed prototypes to test and refine new design concepts before going into full-scale production. Computer hardware engineers have also adopted this strategy. Based on a hardware requirements analysis, a preliminary configuration is designed using off-the-shelf and/or custom-built components. This prototype is then tested and modified until all requirements are met [Ref. 4:p. 9]. More recently, software engineers have seen the applicability of such proven techniques from the older engineering disciplines to their own, and prototyping software is becoming increasingly more common.

There are a number of reasons for prototyping software systems. Sometimes prototypes are warranted because of the high cost or high risk inherent in a given project; consider the relevance of software prototyping to the Strategic Defense Initiative. Certain types of systems (e.g., decision support systems) are best developed using

prototyping because of their lack of structure and non-repetitive nature. [Ref. 3:p. 6]

PQMS does not fall into either of those categories, but there are still compelling reasons for using this approach. Although the role of the Branch Clinic in monitoring physical qualifications is well-understood, those information needs are not easily translated into a formal requirements specification. Even if they were, prototyping is still appropriate in instances where the analysts have no prior experience in building such a system [Ref. 9:p. 228]. This is certainly the case with PQMS. Therefore, the system has been designed as a prototype to clarify the information requirements of the Branch Clinic and to allow for the lack of experience of the analyst/programmer.

D. EXTENSIONS OF PQMS CONCEPTS

The PQMS prototypes a highly specialized, site-specific application. However, there are at least two possible extensions of this system.

The logical design of the system should be adaptable for use by the other service academies. West Point and the Air Force Academy also commission their graduates into a variety of warfare specialties, each with its own physical qualification standards. The Coast Guard Academy sends all graduates to sea duty, but still must determine whether they are physically qualified for a regular Coast Guard

commission. Those who are not must accept commissions in Coast Guard Reserve.

Second, the idea of establishing a knowledge base of physical qualification standards has merit. This knowledge base could be distributed to naval medical treatment facilities, along with programs to compare an individual's physical examination results with those standards. This could provide invaluable assistance in those settings where the health care provider is not familiar with current physical standards or with the waiverability of certain disqualifying conditions. In addition, by building the knowledge base separate from the underlying programs, updates could be easily compiled and issued to field activities, ensuring uniform use of current information throughout the Navy.

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